Integration of Internet-Based Technologies as Learning Tools in a Pharmaceutical Calculations Course

Murali Ramanathan, Robert I. Chau and Robert M. Straubinger

School of Pharmacy, State University of New York at Buffalo, 543 Cooke Hall. Buffalo NY 14260-1200.

The growing prevalence of telecomputing technologies presents instructors with a wide range of options for enhancing the learning experience of students in the Pharmaceutical Sciences and Pharmacy curricula, particularly in large-class settings. However, this wealth of technological resources consists largely of discrete tools developed for purposes other than instruction, and therefore instructors are challenged to devise a unified, integrated approach that both accommodates the very diverse experience and capabilities of students, and satisfies the instructor's need for resilient, robust, and low-maintenance technologies. We describe here an integrated application of technologies for presenting Internet-based resources to students in Pharmaceutical Mathematics and Statistics, a course that serves approximately 100 students per semester in the School of Pharmacy at the State University of New York at Buffalo. We discuss the integration of specific resources with each other and with traditional classroom learning. World Wide Web (WWW) pages are used as repositories both for supplemental material and for archived discussions. Communication among students and instructors is managed via both direct, individual electronic mail (e-mail) and via group-distributed (Listserv) e-mail. By these means, several objectives have been achieved. Communication among students and instructors was enhanced, and discussion among students was promoted. Ancillary course materials were provided to students in a timely and resource-conserving manner, and rapid feedback was provided to students following learning assessment exercises such as exams and quizzes. The model used for integrating Internet-based technologies in this Pharmaceutical Calculations course could be applicable to a variety of large class situations in pharmaceutical education.

INTRODUCTION

Recent advances in telecomputing have brought the realistic possibility of employing new technologies to enhance learning in the Pharmacy and Pharmaceutical Sciences curriculum. With the growth of the World Wide Web (WWW)(1) and the widespread availability of browser programs(2) that display formatted text and graphics, instructors can make a variety of materials available to students electronically, without regard for the hardware and software of the machine on which the information will be viewed. Such "platform independence," is one of the keys to widespread implementation of strategies for distributed- and distance- learning(3,4).

There are many aspects of the Internet that may prove useful in education(5) and a wide range of software tools are at the disposal of instructors. Because most of these tools have evolved independently, and were not necessarily designed to meet educational objectives, this richness of resources present a bewildering variety of possible pathways to implementation. Instructors seeking to introduce new technology into their courses face the task of choosing an initial strategy that is sufficiently limited in scope as to be feasible, flexible enough to support further development, and sufficiently useful to students to encourage the use of the technology. Such considerations were addressed in selecting Internet-related technologies to support student self-learning in a Pharmaceutical Sciences course, and we report here our findings and experiences.

Pharmaceutical Mathematics and Statistics, PHM 311, is the first practice-related course for students entering the School of Pharmacy at the State University of New York at Buffalo (U/B). It was designed to meet the perceived need for students to review and develop their skills in mathematical calculations. The course enrollment is 90-110 students, and is required for both Pharmacy and Pharmaceutical Sciences majors. The course meets for three hours per week, and the material covered includes the interpretation of prescriptions, mathematical calculations used in Pharmacy Practice, and Biostatistics.

Goals. The course emphasizes the importance of accuracy and efficiency in carrying out calculations in a Pharmacy practice setting. The goals of the course are: (*i*) to teach students techniques for identifying, analyzing and solving pharmaceutical problems involving calculations; (*ii*) to hone quantitative problem solving skills, and to prepare students for; (*iii*) quantitative courses in the School of Pharmacy; and (*iv*) the New York State Pharmacy Board Examinations. The course is an academic prerequisite for subsequent courses in Physical Pharmacy, Biopharmaceutics, and Pharmacokinetics.

Format. A modified lecture format is used, and course material is organized into weekly modules. Conceptual and background material is presented in the first class meeting of each week, using a traditional lecture format. Students are provided with background notes at the beginning of the semester, and these materials coincide with the material presented in lecture, so as to minimize the need for extensive note-taking.

The second weekly meeting is an in-class problem-solving session, which uses examples to build a bridge between concepts and quantitative approaches. Practice problems for each module are provided after the first weekly meeting, and an optional review session is managed by a graduate teaching assistant once per week. For most weekly learning modules, calculators are not used in solving quantitative problems, so as to encourage both accuracy in hand calculations and the habitual use of estimation to test the accuracy of calculations.

Student Assessment and Evaluation. The third class meeting of each week consists of a short review session, along with a thirty minute exam. Scoring of the weekly exams is completed as rapidly as possible (usually 1-3 days), in order to provide students with prompt identification of subject matter requiring further effort. Given the consequences of falling behind in a course organized around weekly learning modules, several rapid, direct intervention techniques are used to identify, contact, and work with students encountering problems. For example, students who score less than a 'C grade in any three exams are required to submit solutions to the weekly practice problems. Twelve out of the 14 weekly exam modules are used to compute 80 percent of the student's course grade; the remaining 20 percent is derived from a comprehensive final exam. As an incentive to sustained effort in the course, students who achieve an average grade of A- or better by the last weekly module are exempted from the comprehensive final exam.

In this article we describe: (*i*) the objectives that we sought to accomplish using Internet-based technologies; (*ii*) the strategies and considerations weighed in selecting tools to achieve these objectives; and (*iii*) the methodology and software used to integrate the chosen technologies in support of large-class teaching of pharmaceutical calculations.

METHODOLOGY

Objectives. Several unmet needs in the course were identified. First, it was necessary to make available to students a large amount of both essential and supplemental information, traditionally distributed in printed form, in a more resource-efficient manner. Second, because of the modular, weekly organization of topic areas, students require access to specific problem sets, ancillary and enrichment material, sample examinations, and examination keys on a regular and timely basis. Third, although the majority of students professed a familiarity with electronic and network technology, abilities in this essential area were variable, and quite limited in some students. Fourth, the course proceeds at an ambitious pace and emphasizes self-learning; the instructors therefore sought to increase their availability to students outside of regular office hours when students are actively reviewing material. Finally, it was desirable to provide rapid, direct transmission of test scores to students so that they could undertake remedial actions if needed. We determined that a combination of public and private communication channels were needed.

Student Access Issues. University policy provides for access of all students to extensive computing facilities. Advance coordination between the School of Pharmacy Admissions Office and the University computing center expedited the establishment of computer accounts for the enrolled students.

WEB PAGE RESOURCES

In order to create a single resource to which students could look for information, a World Wide Web (WWW) site was created for the course. From an instructional standpoint, Web pages allowed the instructors to make formatted text, equations, graphics and scanned images available to the students, regardless of the instructors' or students' preferred computer platform.

Location. The course Web site was located at the Uniform Resource Locator (URL) address http://wings.buffalo.edu/academic/department/pharmacy/phc/courses/phc311/. Additionally, a "user account" in the name of the course itself was created within the University computing network, allowing materials to be also accessed using the more intuitive URL, http://wings.buffalo.edu/~phc311/. This latter path is direct, *i.e.*, it eliminates the need to navigate through a hierarchy of other pages, and it allows students without prior knowledge of the URL to find their way to the site from the U/B Web home page (http://wings.buffalo.edu).

Content. The Web pages provided a repository for supplemental class notes, sample exams, exam keys, and archive pages containing cross-referenced copies of on-line discussions (described below). Materials posted on the Web pages included faculty biographies and contact information, class schedules, grading policies, class notes, supplementary materials, and examinations from past years. In the interest of fairness to all students, all old examinations of relevance to the course were posted on the Web site. The retrieval of past exams ultimately comprised the single most frequent use of course Web pages. The dissemination of newly posted materials was observed to be quite rapid.

Content Preparation. All material for posting was created on the instructors' personal computers, using a variety of platform-dependent software tools. For many course materials, the original documents were converted to Rich Text Format (RTF), an interchange format that can be produced by many word processing programs. RTF format documents were subsequently translated into Hypertext Markup Language (HTML), the predominant page description language for Web pages, using the program RTFtoHTML (Table I). RTFtoHTML can be programmed to recognize customized text formatting styles, so that batch conversion of similarly-formatted documents is possible. Many other tools exist for the conversion of formatted or unformatted text into HTML, including Internet Assistant (Table I), a tool that works directly with recent versions of the word processing program Microsoft Word. Internet Assistant eliminates the need for intermediate conversion of documents to RTF. In the majority of cases, some additional formatting of translated material was necessary. Often it was preferable to perform simple editing of the HTML document directly. In other cases, commercial products were employed, such as Internet Assistant (Table I) or PageMill (Adobe Software). It was found that some software products supported only the published standard of the rapidly-evolving HTML page description language, and would silently alter the actual HTML directives in a document, in a manner that would render the pages unreadable. Therefore, backup copies were kept of documents in intermediate stages of development.

Graphical material consisted of illustrations prepared in software or input via a digital scanner. Equations and combinations of intermixed text and graphics (such as example prescriptions) were converted entirely to graphical format to reduce the complexity of page preparation. Handwritten material, such as solution keys to previous examinations, was input by scanner. It was found that the quality of scanned material could vary considerably, depending on which programs were selected for the subsequent processing of the figure. For our graphics,

Table I. A brief description of the software used and their applications

Software	Function	Author/Company URL	Platform availability
Apache HTTP Server	Web server (interface that processes requests for Web pages)	Apache HTTP Server Project http://www.apache.org/	Unix Public omain
ELM	Mail management for mainframe computers	Dave Taylor, USENET Community Trust http://www.myxa.com/elm.html	Unix Freely Distributed
Eudora Lite	Mail management for personal computers	Steve Dorner, Qualcomm Inc. http://www.eudora.com/	Macintosh and PC Freeware
PhotoShop LE	Processing of scanned images.	Adobe Sytems Inc. http://www.adobe.com/	Macintosh and PC Commercial Software
GIFConverter	Converts Graphics Files to popular 'gif format	Kevin Mitchell http://www.kamit.com/gifconverter.html	Macintosh Shareware
LViewPro	Converts Graphics Files to popular 'gif format	MMedia Research Corp. http://world.std.com/~mmedia/	PC Shareware
Listserv	Disseminates e-mail and replies to a group of subscribers	L-Soft International, Inc. http://www.lsoft.com/	Unix Commercial Software
Hypermail	Translates Listserv messages to Web Pages	Tom Gruber, Enterprise Integration Technologies http://www.eit.com/software/hypermail/	Unix Freeware
Internet Assistant	Translates Microsoft Word files to HTML	Microsoft Corporation http://www.microsoft.com/ia	Macintosh and PC Freeware
rtftohtml	Converts formatted text to HTML	Chris Hector (cjh@cray.com) http://www.sunpack.com/RTF/	Macintosh Freeware
Fetch	Facilitates file transfer to and from personal computers and mainframes	Jim Mathews, Dartmouth University www.dartmouth.edu/pages/softdev/fetch.html	Macintosh Shareware
RapidFiler	Facilitates file transfer to and from personal computers and mainframes	Novell, Inc http://www.novell.com/	PC Commercial Software

Adobe PhotoShop LE and GIF Converter (Table I) consistently produced high-quality output.

Graphical material was converted to the CompuServe® Graphical Interchange Format (GIF), which can be displayed on most computer platforms. Many programs are available to convert other graphical formats into GIF. GIFConverter (Table I) is an example of a tool for the Macintosh platform, and LViewPro (Table I) is a tool for the DOS/Windows platform. Both can be obtained from sites on the Internet.

Content Transfer. After creation and editing of the text and graphical information on microcomputer platforms, the HTML pages and GIF format images were transferred to the University's Web server using a file transfer program, such as Fetch or RapidFiler (Table I). Subsequently, key course pages were edited to provide links that students could follow to the new pages.

The time required to create a simple Web page, starting from a formatted Microsoft Word document, typically was 15-30 minutes, and was routinely carried out by the graduate teaching assistant.

Browser Support. It is essential to verify the appearance of Web pages in their final, posted form and it is preferable to use several different browser programs to verify the posted material. However, given the volume of material posted in our course, as well as the short response time often required for posting supplemental information, a decision was made to limit the effort devoted to page verification. Because of the graphics-rich nature of our material, we decided not to support non-graphical (text-only) browsers and gave no specific consideration to the appearance of Web pages on browsers other than the widely-available Netscape program which has been selected for installation at this University's student computing sites. The course Web pages were proofed with an older version of Netscape (Version 1.1), to ensure that the quality of the presentation was not compromised if students used an older version of that program.

Nonstudent Access to Course Materials. The server software used at the University of Buffalo (Apache version 1.1.1) can restrict access either to specific users (with passwords) or to specific Internet domain addresses. Access to our course materials was restricted to the network domain .buffalo.edu. This domain includes the entire University of

Buffalo computer network, as well as a free public-access service provided by the University (http://freenet.buffalo.edu). Although simple to implement, a shortcoming of such domain-based access control is that students or faculty who use commercial providers for Internet access are unable to view course materials. However, no requests for external access were received from students, and the rapid evolution of server and browser software has provided the means to overcome this limitation, if necessary.

A careful consideration of several issues led to restriction of access. First, students were encouraged to discuss material they did not understand; world-wide distribution of such unfettered discussion would serve no positive purpose, and would cause some students discomfort. Second, most quantitative problems are posed to students in the form of prescriptions. Although some degree of realism was sought in creating the problems, non-students entering the Web site should not mistake the contrived prescriptions for accurate prescribing information.

LISTSERV GROUP E-MAIL COMMUNICATIONS

An active, direct conduit for communication and discussion among students and faculty was created using a Listserv e-mail distribution program (Table I). Listserv software propagates any e-mail message sent to the address phc311-list@listserv.acsu.buffalo.edu to a list of subscribers. One advantage of the Listserv is the large number of students and faculty who are at ease using e-mail. The rationale for setting up a Listserv subscriber list for the course was to allow students to present and discuss course-related information with other students, and to provide the instructors with a means to broadcast announcements to the class. The Listserv permits the categorization of discussions by topic, and replies to previous messages are propagated to the entire group.

Electronic "chat rooms" similarly can promote discussion. However, chat room responses tend to be spontaneous and often low in information content. Additionally, the information is available only to participants who are logged on during the discussion. A "chat room" was installed in the course Web site primarily for use during "virtual office hours" but we did not have it on-line long enough to assess its impact on learning.

Structure and Access. Subscription to the Listserv list was optional, and approximately 50 percent of students joined the Listserv list within the first four weeks of the course. The percentage rose to 85 percent after students were offered an inducement of five bonus points to be added to one of the weekly exams if they were on the Listserv subscriber list by a particular date. This scheme allowed us to motivate procrastinating students and to reward those who joined early.

We chose to restrict list membership to students and instructors, and to allow un-moderated posting of messages by any member of the list. Experience showed this to be a fortuitous combination of options; the un-moderated discussion allowed rapid and free exchange of messages outside of working hours, and the requirement for instructor approval to join the Listserv discussion group prevented undesirable postings to the class list by mischievous individuals on the Internet.

List Creation and Maintenance. We used Listserv software maintained by the Computing and Information Technology (CIT) unit of U/B. The task of creating and maintaining a Listserv list can be perplexing, owing to arcane commands and the confusing distinction between the Listserv discussion list e-mail address, to which messages for the class are mailed, and the e-mail address of the Listserv program itself, to which commands are sent to control the operation of the mail distribution program. We took advantage of tools created by CIT staff to assist in list management. These aids include a simple form, placed on a University Web page (http://wings.buffalo.edu/listserv/list-req.html) that allows on-line requests for the creation of new Listserv discussion lists. Other aids include on-line documentation for Listserv list use and management, with links to both locally-produced materials and to more detailed documentation maintained by the Listserv software vendor (http://www.lsoft.com/manuals/owner/appenda.html#mgt). In practice, managing the Listserv discussion list required little effort once the group was established.

INDIVIDUAL E-MAILCOMMUNICATIONS

Direct, individual electronic mail tools were utilized to allow confidential or one-on-one communication between the instructors and the students. Students frequently e-mailed questions to instructors directly, rather than to the Listserv discussion group, perhaps perceiving potential embarrassment in posing their questions publicly. Such individual questions, where generally relevant to the course, were stripped of identifying information and forwarded by the instructor to the Listserv list, along with the instructor's response.

Grade Notification. In order to meet the objective of providing students with rapid, confidential notification of their quiz and exam grades, a Perl-language script called RGNS (Rapid Grade Notification System) was developed and placed in the instructors' area on the University's UNIX host. RGNS provided the instructors with the ability to e-mail grades or other information directly to individual students from a tabular file such as a spreadsheet (*e.g.,* generated by Microsoft Excel). Typically, a spreadsheet file containing student e-mail addresses, course grades, and exam scores was saved in tab-delimited, text-only format, transferred to the UNIX host using a file-transfer program, and individual e-mail messages were dispatched using RGNS. RGNS obviated the need to post paper lists of student grades, and was well-accepted by students. Source code for RGNS will be provided to educators on request.

Instructor Information Management. The significant reliance on e-mail for course activities requires instructors to receive, organize, re-direct, and answer e-mail efficiently. Instructors used microcomputer-based e-mail programs to assist with organizing and managing course mail. One program used was Eudora (Table I), which is available for both Macintosh and DOS/Windows platforms, and which is produced both as a basic, freely-distributed version and as an enhanced-features commercial version. Eudora was configured to collect mail at regular, frequent intervals from the University mail server, and to send outgoing mail. Important capabilities for a mail-handling programs include ease of forwarding and re-directing mail.

INTEGRATION OF WEB PAGES, LISTSERV, AND DIRECT E-MAIL RESOURCES

A schematic outlining the integration between the Web pages, the Listserv and the electronic mail is shown in Figure 1, and the interrelationships among these technologies are described here.

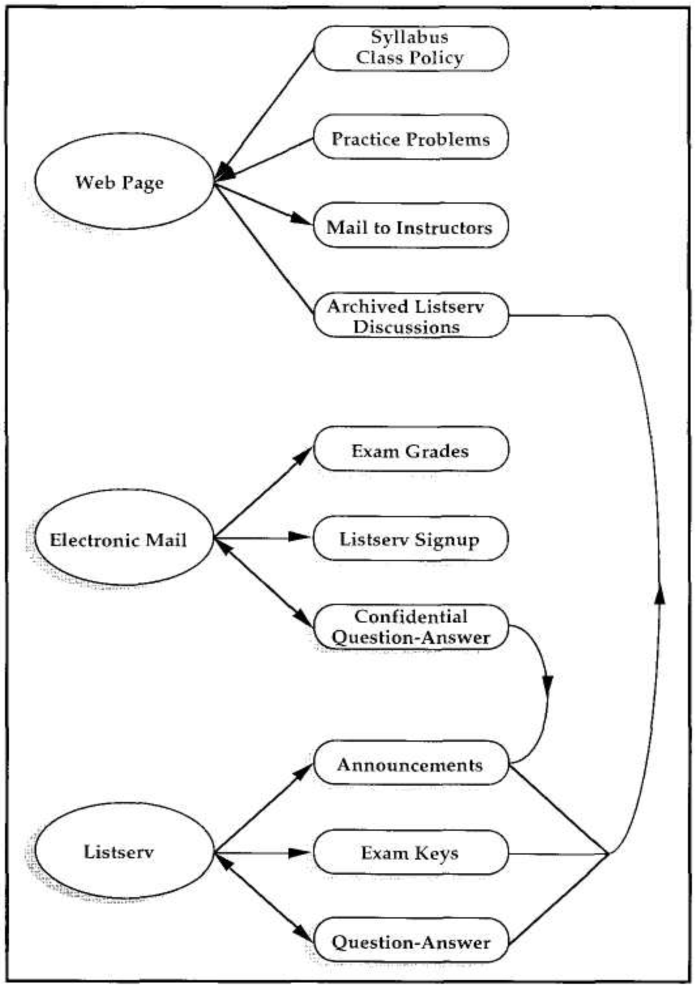

Fig 1. Integration of Internet-based technologies. The Figure shows the course content placed on the Web, the Listserv and the e-mail and the interrelationships between the three Internet-based resources

Integration of the Listserv with the Web. One major disadvantage of the Listserv tool is that e-mail is predominantly a text-only medium, with limited capability to handle equations and graphics. In addition, arcane Listserv commands make it difficult for students to retrieve lost messages; a late entrant in a discussion may have difficulty in retrieving previously-posted material of relevance. To overcome the latter problem, a software tool was used for automatic archiving of Listserv e-mail discussion in the form of Web pages. Hypermail (Table I) is a publicly-available program that runs on several platforms, and which produces indexed, cross-referenced Web pages from e-mail messages. Hypermail converts messages into HTML, and then indexes them by subject, date, and author. Messages comprising a particular discussion thread contain links to both the previous and subsequent messages in the discussion. An additional capability of Hypermail is the capacity to recognize and convert URL addresses that appear in e-mail messages into active links in the Web pages created, thereby embedding links to graphics or other Web pages. In addition, e-mail addresses in Listserv messages are recognized by Hypermail and converted into active links that initiate e-mail to the addressee directly from the Web page.

To allow unattended archiving of Listserv discussions as Web pages, a link was created between the Listserv list and the Hypermail conversion tool. A "user account" in the

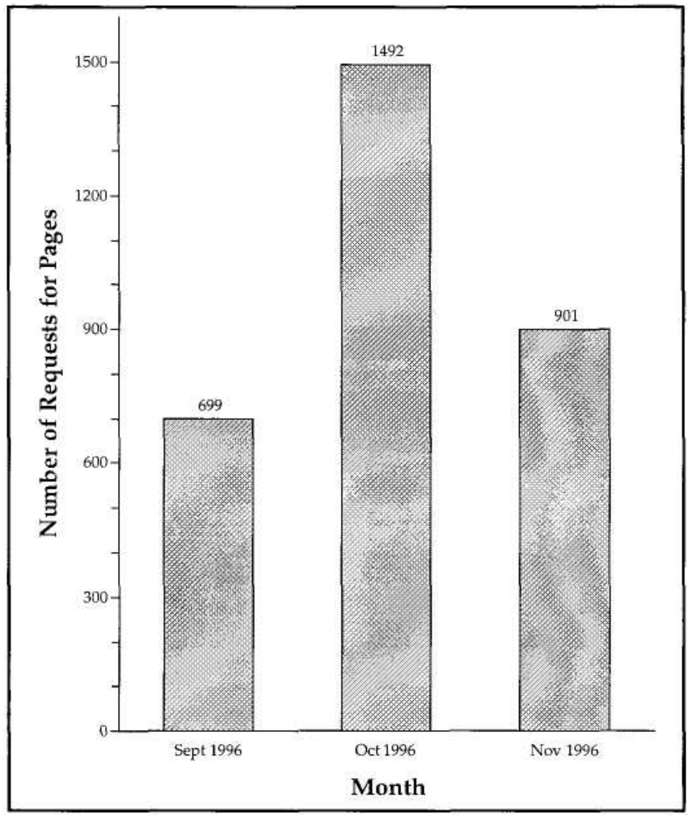

Fig. 2. Statistics on the requests for course Web pages arranged by month. The data was generated by the U/B Computing and Instructional Technology Department. The rapid increase in Web page usage within the first month suggests that students began using the Internet fairly rapily.

name of the course was created. This 'user' was subscribed to the course Listserv list, and therefore received the e-mail discussions of the course. All e-mail received by this 'user' was passed automatically to an e-mail filter of the Elm software package (Table I). Those messages originating from the course Listserv list were selected by the Elm filter and passed to Hypermail for formatting, cross-referencing, and installation into the course Web site.

Integration of the Web with the Listserv and E-mail. We created a sign-up form on the course Web page to make the task of joining the discussion list easier for students and links to an e-mail interface program were added to the Web pages to allow students to e-mail the instructors directly from the Web page. In this way, students did not have to remember e-mail addresses in order to contact faculty. In addition, a class e-mail directory was set up, so that students could contact each other directly. Whenever the course Listserv subscriber list changed, the new subscriber list was e-mailed to the course 'user'. An Elm filter directed the list to Hypermail, which then converted the e-mail addresses into links and installed the page in the Web site.

STUDENT RESPONSE TO INTERNET RESOURCES

Student utilization of these Internet-based resources grew rapidly. To assess student acceptance, we evaluated both a student survey at the end of the course and the Web page usage statistics generated by the Apache Web server (Table I).

Figure 2 shows the monthly usage of the course Web pages. Despite the absence of structured classroom instruc-

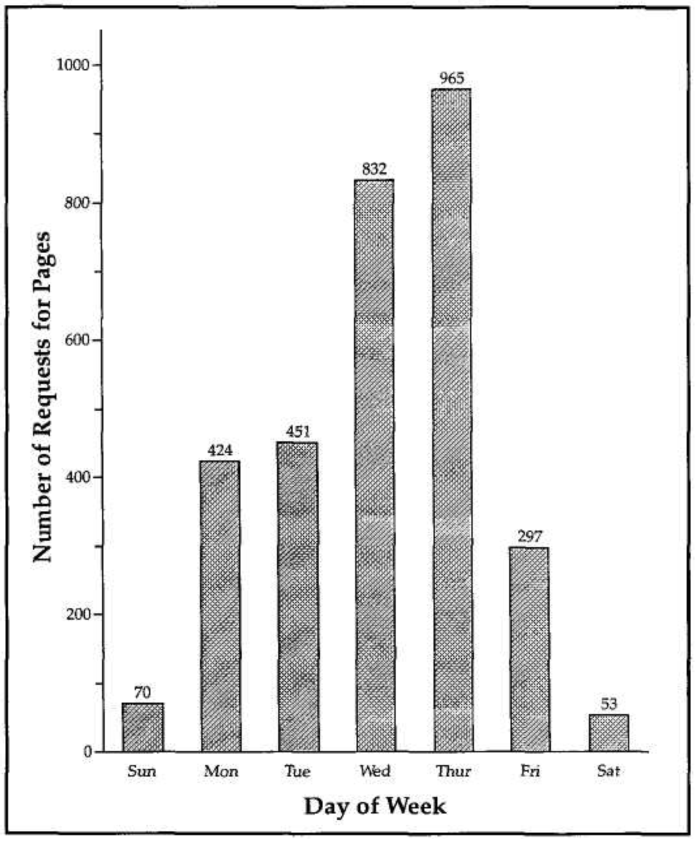

Fig. 3. Statistics on the requests for course Web pages arranged by day of week. The data was generated by the U/B Computing and Instructional Technology Department. Web page requests increased on Wednesday and Thursday because of the weekly exam was given every Friday. For this course, the peak daily usage rate was more than twice the average rate.

tion on using these Internet-based resources, there were a substantial number of Web page accesses within the first month, suggesting that students sought and used the material posted. We were unable to obtain an estimate of the number of course Web pages subsequently printed, but it appeared that a large number of students preferred to work from paper copies generated from the Web page. This dependence on paper copies may decrease as computers become more prevalent and students become more secure in the notion that the Web page information is always available. Interestingly, there was a large increase in Web page usage on Wednesday and Thursday (Figure 3), immediately preceding the weekly exam given on Friday. Figure 3 also shows that for this rapid-paced, information-intensive course, the peak usage rate was more than twice the average usage rate.

Tables II-V show data obtained from a class evaluation survey administered at the end of the course. Nine questions related to Internet-based learning comprised approximately 13 percent of the survey. As an incentive to completing the survey, 0.5 percent points were added to the responding students' final course score. We obtained a response rate of 81 percent (n=100 students).

Table III summarizes the prior computer experience of the students in the course. We were somewhat surprised to find that the majority of students in the class had used electronic mail previously (84 percent) and/or the Internet (75 percent). In contrast, the fraction of the class that had used Listserv previously was much smaller.

Table II. Prior experience of the class with Internet technologies

Survey question	No[a]	Yes[a]
Do you own a personal computer?	41 (51)*	40 (49)
Did you use the Internet before this class?	21 (26)	60 (74)
Did you use a Discussion list (listserv) before this class?	66 (81)	15(19)
Did you use e-mail before this class?	13 (16)	68 (84)

[a]Responses are shown both as a number and, in parentheses, as a percentage.

In Table IV, we show the student responses to individual resources. In each instance, Web, Listserv and e-mail, a clear majority of the class found the resource to be greater than "average" in usefulness. Fifty nine percent of the class found the Web pages "very useful" and the corresponding frequencies for the e-mail and the Listserv resources were 53 percent and 40 percent, respectively.

The overall student impressions of the Internet-based resources are summarized in Table V. The assessments were very favorable and the majority the students found that the use of Internet-based resources helped them learn the material in PHC 311.

DISCUSSION

A number of problems were anticipated or encountered as Internet-based technologies were integrated into the course Pharmaceutical Mathematics and Statistics. The transition to Internet-based course materials can place significant one-time resource demands on instructors, students, and facilities. Informally, we classified problems encountered during the transition period into three categories: (*i*) content-related problems caused by the need to convert instructional materials into a form suitable for posting as Internet-accessed resources; (*ii*) facilitation problems caused by a large number of student queries directed to teaching assistants and computer Help Desk personnel; and (*iii*) hardware/software problems caused by the increased load on institutional computer resources. In our experience, the impact of these pitfalls can be reduced by advance planning on the part of the individual instructor. Coordination among the instructor, Department/School, and the institutional computer center may be essential at most sites.

The need to produce or convert materials specifically for display using Internet-based technology can place considerable demands on instructors' time; at present, we are inter-converting materials for presentation in 3 media: print; overhead transparency and Web pages. The amount of time consumed in making such inter-conversions can be lessened by preparing materials for in-class overheads, class notes, examinations, and Web pages in an integrated fashion. For example, many word-processing programs (*e.g.,* Microsoft Word) support the naming of specific paragraph formats or styles. By applying such named styles consistently in formatting overheads, notes, and exams, inter-conversion was expedited considerably. For example, consistent application of named paragraph styles allowed the material to be reformatted easily for presentation programs (*e.g.*, Microsoft PowerPoint 4.0), for overheads, and (using tools such as RTFtoHTML or Internet Assistant) for Web pages. The consistent use of named text styles greatly reduced the requirement for hand-optimizing the formatting of HTML

Table III. Student responses to individual Internet resources

Survey Question	Percent student t response on an ordinal scale Useless	2	Average	4	Very useful
Did you find the Web page useful?	5.0	2.5	19	14	60
Did you find the Listserv useful?	13	5.0	20	23	40
Did you find the e-mail useful?	3.7	7.4	14	22	53

Table IV. Overall student assessment of Internet technologies

Survey question	Percent student response on an ordinal scale Useless	2	Average	4	Very useful
Overall, what do you think of what we did with computers?	0.0	6.3	14	30	50
Overall, did the computer tools help with learning in PHC 311?	3.7	6.2	20	33	37

Web pages. To reduce editing time further, we also developed templates for routinely occurring graphics such as prescriptions. These changes allowed us to instruct teaching assistants in preparing, organizing, and maintaining the instructional content of the course Web pages.

The facilitation problems encountered were minimal for several reasons. Foremost among them is the fact that efforts to integrate new learning technologies into the Pharmacy curriculum is both encouraged and actively supported at the level of the School and the University. Resources have been allocated over the past two years to provide a microcomputer laboratory within the School. Support personnel already were in place. The School of Pharmacy Office of Admissions coordinated efforts with managers in Computing and Information Technology to ensure that all students enrolled in the course were assigned computer accounts during the pre-semester orientation, to avoid delays in student utilization of the technology resources. For students in need of coaching, student volunteers staffed the computer laboratory. We also established a peer help system, and encouraged students who were familiar with the technologies to help those who required assistance. Finally, the School of Pharmacy also provided the instructors with the services of a student programmer for four hours per week. The programmer developed small tools such as RGNS, program scripts to work with more sophisticated special-purpose Web pages, and evaluated solutions to various problems and needs that occurred during the semester. The combined effect to these institutional factors made the introduction of Internet-based technologies easier for students and instructors alike.

Some potential pitfalls bear special mention. Worldwide, the use of telecomputing technologies is undergoing an unprecedented rate of increase, and demand often exceeds the capacity of Web- and e-mail servers. Within educational institutions, such growth has similar effects. First, the adoption of Internet-based technologies in a large classroom setting rapidly converts significant numbers of dormant user accounts into active users. This general increase in computing demand can place severe strains even on large computing infrastructures. Second, a reduction in the amount of course information distributed in paper form was somewhat offset by an increase in the demand for computer printing facilities. Third, specific resources may fail under unprecedented load. In our experience, severe delays in e-mail delivery began early in the semester, with the delivery time for messages often ranging from one to three days. This failure often rendered e-mail useless for student discussions of urgent questions. In addition, high demand for dialup telephone connections to the University computers interfered significantly with the instructors' intent to provide 'virtual office hours' on evenings and weekends. These problems undermined efforts to foster student reliance on the Internet-based technologies as a first-line resource for course help and information, and likely tempered student enthusiasm, as evidenced in the course survey.

The impact of some of the these institutional hardware and software problems can be softened by planning and by coordination between the computer center personnel and the academic departments. Our strategy for managing the course included the use of redundant Internet-based resources. For example, when e-mail delivery was hindered, Web pages remained accessible. Instructors therefore could respond rapidly to student needs for information. However, our overall experience makes clear that demand on facilities may rapidly outstrip near-term institutional planning, and require capital equipment outlays to combat the effects of increased load.

In conclusion, we have introduced Internet-based technologies in an integrated fashion at an early stage in the Pharmacy curriculum. Student acceptance and utilization grew in proportion to the perceived usefulness of the information provided. The use of the Internet as an adjunct teaching tool in a large classroom setting can enrich the student learning experience and enhance student-instructor-student communication, and can foster the development of information-technology skills that will be useful to the students both in the School of Pharmacy and in the profession. Additional studies are clearly needed to assess the ability of these technologies to increase student understanding and to promote long term learning.

Acknowledgments. Additional information on the organization of the site is available at http://wings.buffalo.edu/academic/department/pharmacy/phc/courses/toEducators.html. A considerable number of individuals contributed both to the overall strategy and specific details of implementation. In particular, we thank Zerxes Bhagalia for writing the RGNS program and for suggesting and implementing the Elm filter to direct Listserv mail to Hypermail, Dr. Sarbani Banerjee (UB Department of Pharmacy Practice) for advice and help, and for developing the School of Pharmacy microcomputer lab, Dr. Ray Magauran (UB Department of Ophthalmology) for advice on Hypermail, Jim Gerland (UB Computing and Information Technology) for a great deal of patient and prompt help on wide-ranging problems, and Ross Winston (CIT) and Hugh Jarvis (CIT/UB Anthropology) for help with HTML problems and strategies. Commercial software is mentioned by name only to provide specific examples of tools available for particular tasks, and is not meant to indicate endorsement or suitability. This project was funded from various sources, including the School of Pharmacy and the Office of the Provost, State University of New York at Buffalo.

Am. J. Pharm. Educ., **61**, 141-148(1997) received 12/13/96, accepted 4/10/97.

References

(1) Segal B., "A Short History of Internet Protocols at CERN," downloaded 12/4/96. (http://wwwcn.cern.ch/pdp/ben/TCPHIST.html.)

(2) Mosaic was the first visual browser developed for the Internet in 1993. It is available from the National Center for Supercomputing Applications at the University of Illinois in Urbana-Champaign. It may be downloaded at www.ncsa.uiuc.edu/SDG/Software/Mosaic/. Netscape is a visual browser developed by Marc Andreesen and his colleagues after they left NCSA in 1994. It may be downloaded at home.netscape.com/. Internet Explorer is a visual browser developed by Microsoft Corporation in 1995. It may be downloaded at www.microsoft.com/ie/.

(3) Kerka, S., "Distance learning, the Internet and the World Wide Web," *ERIC Digest,* **168**, 3-4(1996).

(4) Burgstahler, S.E., "Distance learning and the information highway," J. Rehabilitation Admin., **19**, 271-276(1995).

(5) Barrie, J.M. and Presti, D.M., "The World Wide Web as an instructional tool," *Science*, **272**, 371-372(1996).